APPARATUS AND METHOD FOR OBTAINING THREE-DIMENSIONAL POSITIONAL DATA FROM A TWO-DIMENSIONAL CAPTURED IMAGE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a US National Stage of International Application No. PCT/GB02/00738 filed 22 Feb. 2002. This application claims the benefit of Great Britain Application No. 0104456.9 filed 23 Feb. 2001. The disclosure(s) of the above applications are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to apparatus and methods for determining one, two and three-dimensional positional data from a two-dimensional image and particularly, although not exclusively, to apparatus and methods for determining three-dimensional positional data from a two-dimensional captured image of a field of view comprising at least two optical markers.

BACKGROUND TO THE INVENTION

Prior art cameras incorporate a light-sensitive media in the form of an insertable film on which the image captured by the camera is formed. As a general rule, the larger the film format, the finer the quality of image. Such films use a chemical process to form the image, the image being fixed onto a hard copy format e.g. paper. Such films produce an image as a gradient, the image not being formed by a number of identifiable and measurable image quanta. From this traditional chemical film format, semi-conductor arrays have been developed for capturing images via the sensing of light and production of a plurality of digitised signals. Examples of such digital image plates known in the prior art are the CCD (Charged Couple Device) and CMOS (Complementary MOS) arrays.

CCD and CMOS arrays comprise a plurality of photo-sensitive elements which each generate a pixel of data. Each pixel of data is then combined with adjacent pixels of data to produce an image of the entire field of view. Each pixel therefore has a pixel size of measurable physical dimensions which can be determined. These physical dimensions can be related to known positions in the field of view.

Prior art devices and methods have taken advantage of the CCD array to accurately measure distances between a digital camera and objects in a field of view. This type of range finding is illustrated in the following prior art documents: GB 2344012, EP 0205175, DE 4238891, JP 07294216, JP 08005370, JP 08094324, JP 09304055, DE 19736588, DE 29921143 U1, DE 19949838, JP 08285633, JP 11094520, JP 2000121354, U.S. Pat. No. 6,094,270. These prior art references are concerned with measuring distances from an object to an image plate or lens including methods of eliminating information of low reliability.

In these prior art documents it is apparent that range finding has become possible using CCD image plates and a marker introduced to the field of view. The CCD enables the pixel dimensions to be determined, and determining the characteristics of the markers introduced to the image enables trigonometrical surveys and Pythagoras calculations to obtain the distance from the image plate to the object in view.

EP 0205175 discloses the use of a plurality of cameras to obtain distance information relating a robot arm to an object. Determination of arm position is made as a relative determination between known points and does not provide information for all points in the field of view of one camera. Additionally, a plurality of cameras are required to provide image information in more than two dimensions.

U.S. Pat. No. 6,094,270 is concerned with real time range finding. A sweeping light projection is required and an analysis of reflective light intensity is required to be adjusted to account for changes in reflectance characteristics of a surface dependent on the wavelength of incident light. It is necessary for a sweep of light to traverse the entire field of view to establish positional data about that field of view by a simple range finding to each point swept by the beam of light.

EP 0145957 A1 discloses a method in which the distance between an imaging optic and an object is determined. A light spot is projected onto an object, the light source being apertured to provide a non-diverging light beam wherein the light spot formed on the object is of known diameter and area. The method relies upon initially determining a reference point wherein the light spot strikes the object plane at a normal to the imaging optic. Projecting the light spot at a point of interest on the object results in a distortion of the light spot dependent upon the contour of the object surface. A correction for the distortion between the measured object surface and the normal is obtained by a triangulation method. This method can only correct for one aspect of the orientation of the plane of the imaging plate with respect to the object plane, that is, only a calculation of the change in tilt or pan can be made. The method further requires a pre-initializing or calibration step wherein it is necessary to locate the reference light spot at the centre of the image in order to determine the normal values. It is necessary to further use a non-diverging beam in order to project a light spot of consistent known size. As a pre-initializing step is required before a measurement step more than one imaging operation is required to determine distance information. Further, a plurality of measuring operations are required to determine three-dimensional positional data regarding the object as it is only possible to measure one orientation aspect of the image plate with respect to the object plane at any one time. Further, in order to determine three-dimensional positional data regarding a plurality of surface points of the object it is necessary to scan the imaging optic across the object. This may further combine a displacement of the imaging optic relevant to the object in order to determine the distance between image plate and object plane at any chosen point of interest on the object plane.

EP 0224237 A1 discloses a system for locating an object. The system comprises an approach sensor for optically scanning and a light source for light transmission towards an object comprising several target patterns in the form of pairs of coded patterns which can be read optically. The sensor is capable of receiving light reflected from the target patterns in order to measure functions of time and angle of the sensor from the pairs of patterns so as to locate the object specifically with respect to the sensor. This system is a comparator wherein time and angular displacement measurements are determined in order to determine a relative spatial position of the sensor to the object. No information regarding the three-dimensional position of the object surface plane at a point of interest is provided.

U.S. Pat. No. 5,915,033 relies on a pair of image sensing devices to correct the error in the distance detected in an image detection module including an optical device. The